Comparison of Pain Perception Using Conventional Versus Computer-Controlled Intraligamentary Local Anesthetic Injection for Extraction of Primary Molars

Meenu Mittal, BDS, MDS,* Radhika Chopra, BDS, MDS,† Ashok Kumar, BDS, MDS,‡ and Dhirendra Srivastava, BDS, MDS, MOMS, RCPS (Glasgow)§

*Professor, Department of Pediatric Dentistry, Employee State Insurance Corporation (ESIC) Dental College, Rohini, Delhi, India, †Professor, Department of Pediatric Dentistry, ITS Dental College & Research, Muradnagar, UP, India, ‡Associate Professor, Department of Pediatric Dentistry, ESIC Dental College, Rohini, Delhi, India, and §Professor, Department of Oral Surgery, ESIC Dental College, Rohini, Delhi, India.

This study was conducted to compare pain perception of intraligamentary anesthesia (ILA) using a computer-controlled local anesthetic delivery system (CCLADS) versus a conventional intraligamentary injection for extraction of primary molars. A randomized controlled trial was designed where 82 children requiring 102 primary molar extractions were given ILA of 2% lidocaine with 1:80,000 epinephrine with either the conventional method or a CCLADS. Pain during injection and extraction was assessed using the Sound, Eye, Motor (SEM) scale and heart rate recording. Faces Pain Scale–Revised (FPS) scores were self-reported by patients. The Mann-Whitney test was used for evaluation of FPS and SEM scores and Student's *t* test for evaluation of heart rate readings. Heart rate values during injection were found to be higher, but not statistically significantly higher ($p = .077$), for conventional injection versus CCLADS; however, heart rate values during extraction were significantly higher for the conventional method ($p = .009$). Both FPS and SEM values were found to be significantly higher for conventional ILA technique ($p < .05$). ILA can be an effective alternative means of anesthesia for primary molar extractions, and CCLADS devices can make ILA more effective and less painful.

Key Words: Intraligamentary anesthesia; Local anesthesia; Dental extraction; Primary molars.

Local anesthesia is the pillar upon which modern dentistry stands. Local anesthetics are the safest and most effective methods of management of pain associated with dental treatment. Commonly used methods for achieving local anesthesia are local infiltration and nerve block.[1] These techniques have some limitations. With residual soft tissue anesthesia, the patient may accidentally bite the soft tissue, inflicting potentially significant traumatic injury, especially in infants, children, and patients with special health care needs.[2] Also, to obtain sufficient anesthesia of the desired region, relatively large doses of anesthetic agent may be required.[1]

In intraligamentary anesthesia (ILA), anesthetic solution is injected with pressure in the periodontal ligament (PDL) space and placed directly into the cancellous bone adjacent to the tooth to be anesthetized.[3] With ILA, specific teeth are anesthetized with less residual and soft tissue anesthesia, and thus discomfort and potential self-mutilation of nerve block anesthesia are avoided.[4] However, there are some potential problems with the conventional intraligamentary technique. One such problem is the high pressure required to inject the anesthetic solution, which may lead to breakage of the glass cartridge with a conventional syringe.[5] Also, ILA can be a painful injection, as the local anesthetic solution is injected under pressure. Various computer-controlled local anesthetic delivery systems (CCLADSs) are now available that can adjust the volume, pressure, and speed at which anesthetic solution is delivered, reducing tissue distortion and thus potentially minimizing the painful experience of ILA. The Wand-STA Single Tooth Anesthesia CCLADS (Milestone Scientific Inc, Livingston, NJ) was launched in dentistry in 2006 by the manufacturers of the Wand-Compudent system. It utilizes dynamic pressure-sensing

Received March 29, 2018; accepted for publication September 25, 2018.

Address correspondence to Dr Meenu Mittal, A- 29 Ground Floor, Hauz Khas, New Delhi, India; meenu20feb@gmail.com.

Anesth Prog 66:69–76 2019 | DOI 10.2344/anpr-66-01-09

technology and can provide more precise and accurate delivery of local anesthetic solution to a single tooth via the intraligamental route.

Various studies in the literature report adequate anesthesia with intraligamentary injection for primary tooth cavity preparation and pulpectomy as well as permanent tooth extraction.[6–9] Limited studies have been conducted to evaluate the efficacy of ILA for extraction of primary molars and compare it with STA CCLADS ILA. A PubMed search using keywords PDL/intraligamentary anesthesia, primary molars revealed 11 studies, most of which were about the efficacy of PDL anesthesia for pulpotomy/endodontic procedures and only 4 about extraction, of which 2 were about the use of ILA for management of postextraction pain.

The present study was conducted to compare pain perception and anesthetic efficacy of conventional ILA and the STA CCLADS ILA for extraction of primary molars.

METHODS

Following a literature survey, the expected mean ± SD pain report using the Faces Pain Scale during injection for STA and conventional groups was found to be 2.15 ± 1.72 and 1.10 ± 1.12 respectively. For α error probability 5%, power ($1 - \beta$ error probability) 95%, and effect size 0.7215, with the help of G*Power analysis version 3.1.9.2, software developed by Franz Faul, University Kiet, Germany, the sample size was calculated to be 51 for each group for expected data.

One hundred two procedures were performed on 82 children aged 6–13 years who were undergoing treatment at the Department of Pediatric & Preventive Dentistry at ESIC Dental College. Selection criteria for the patients included the need for extraction of a primary molar, Frankl behavior rating of III or IV (positive or definitely positive), the absence of inflammation or infection in PDL of the tooth to be extracted, and no history of allergy to local anesthetic solutions. None of the patients were treated under conscious sedation or received any treatment that could modify their behavior or awareness of pain. Informed consent from parents was obtained before starting the treatment.

Ethical approval to conduct the study was taken from the Institutional Ethical Committee of ESIC Dental College, Rohini, Delhi, India. A randomized controlled trial design was used wherein each child was randomly assigned by envelope method to receive ILA by either the conventional or computerized method. Study subjects were not informed about the group allocation.

Preoperative radiographs were taken before extractions. Tissues were dried with gauze and lidocaine spray (Xylonor spray, Septodont, Saint-Maur-des-Fosses, France) applied at the injection site and left in place for 1 minute. Injection sites for ILA were the mesial and distal root PDL space of mandibular molars and the mesial, distal, and palatal root PDL space of maxillary molars. The injection was given first on the distal line angle, then on the mesial line angle. A standard aspirating syringe (Septodont) was used for the conventional method and the Wand-STA Single Tooth Anesthesia System CCLADS was used for computerized intraligamentary injection. For both techniques, a 30-gauge, 1.27-cm (half-inch) needle and 2% lidocaine with epinephrine 1:80,000 (Lignospan special, Septodont) were used.

A standard technique of ILA injection was followed. The tooth was approached at approximately 45° to the vertical plane. The needle was placed in the gingival sulcus with the bevel towards the tooth and was slowly moved in the direction of the root apex till resistance was felt. For conventional ILA, the anesthetic solution was injected at this position. For CCLADS, the needle was held at the same position without excessive pressure and was further guided by constant audible and visual feedback. The visual pressure-sensing scale comprises a series of LED lights (orange, yellow, and green). The orange light indicates minimal pressure, the yellow indicates mild to moderate pressure, and the green means moderate pressure indicative of entering PDL tissue. If a high yellow or green signal was not indicated, the needle was withdrawn and was repositioned until a high yellow or green signal was observed. The correct position of STA PDL injection (high yellow/green, as per the STA CCLADS manual) was achieved in all the children. Approximately 0.36 mL of anesthetic solution was used per injection in both the groups. Circumferential gingival blanching was observed in both conventional and CCLADS methods.

Two researchers conducted the study. The primary researcher performed all the injections and extractions. The second researcher (evaluator) was an impartial observer who recorded all the scores.

In the Sound, Eye, Motor (SEM) scale, sound, eye and motor pain reactions of the patient are observed and assigned to 4 categories: comfort, mild discomfort, moderately painful, and painful.[10] The SEM score was recorded by a single researcher standing at a distance of 1.5 m from the dental chair during injection and extraction. The first researcher trained the second researcher on assigning the SEM scales, and they calibrated before starting the study. For calibration, 10 children requiring local anesthesia, who were not included in the study, were observed by the 2

researchers, who rated them independently. Disagreements in rating were discussed until full agreement was reached. Intraevaluator kappa values for the second researcher were 0.7.

Heart rate was used as an indirect physiological indicator of pain response in this investigation and was recorded using a pulse oximeter (Truscope Mini, Schiller AG, Baar, Switzerland). Readings were taken at 3 intervals: pretreatment, during injection, and during extraction. Reading 1, preinjection, was calculated as the average of readings taken at 2-minute intervals for 8 minutes before administration of the anesthetic injection. Reading 2, recorded during the anesthetic injection, was the average of 4 readings taken at 15-second intervals during the injection. Reading 3, recorded during the extraction procedure, was the average of 4 readings taken at 15-second intervals during the extraction procedure.

Immediately after injection, the second researcher showed the patient the Faces Pain Scale–Revised (FPS) and asked the patient to point to and mark the face that corresponded to the amount of pain he or she had perceived during the injection. The patient was also asked to again record the FPS immediately after the extraction to indicate the amount of pain during the extraction.

All the collected data were analyzed by statistical software SPSS version 16.0 (SPSS Inc, Chicago, Ill). The significance of heart rate differences between 2 groups at different time intervals was evaluated by t test for independent groups and paired t test for intragroup comparison, and nonnormal data like FPS and SEM pain scores were evaluated by Mann-Whitney U test. The agreement between the raters was done by kappa test. The level of significance and confidence interval was 5% and 95% respectively.

RESULTS

A total of 102 procedures were performed on 82 patients aged 6 to 13 years (mean age = 8.5 years), of whom 47 were males and 35 females. Table 1 shows the groupwise demographic details for both groups. There were no significant differences between the groups.

Assessment of Heart Rate Values at Various Stages of the Procedure

The mean heart rate values during conventional injection were not significantly different than during CCLADS (105.7 ± 14.8 vs 101 ± 12, $p = .077$). However, when these values were analyzed separately for maxillary and mandibular injections, the maxillary injections showed significantly higher heart rate values with conventional ILA versus CCLADS (110.1 ± 13.6 and 102.3 ± 12, $p = .03$). Also, higher heart rate values during injection were obtained for primary second molars versus primary first molars when conventional ILA was used as compared to CCLADS (110.4 ± 11.5 vs 102.9 ± 10.7, $p = .03$) (Table 2).

The mean heart rate value during extraction with conventional ILA was significantly higher than the value with CCLADS (109.3 ± 14.5 vs 102 ± 13, $p = .009$). When these values were separately analyzed, this difference was evident for maxillary extractions and for both primary first and second molars, but not for mandibular extractions ($p = .37$) (Table 2).

Table 1. Demographic Information of Both Groups

	Conventional ILA (n = 51)		*CCLADS (n = 51)*	
	No.	*%*	*No.*	*%*
Sex				
Male	35	68.2	34	66.6
Female	16	31.7	17	33.3
Age range, y				
6–8	11	21.5	9	17.64
8–10	20	39.21	15	29.41
10–13	20	39.21	27	52.9

* ILA indicates intraligamentary anesthesia; CCLADS, computer-controlled local anesthetic delivery system. $p > 0.05$ for all comparisons.

Assessment of FPS and SEM Scales

Table 3 shows the median values of the FPS and the SEM scale during injection and extraction for the conventional ILA and CCLADS groups. When analyzed using the Mann-Whitney test, all values were found to be significantly higher for the conventional ILA technique, indicating that the injection, as well as the extraction procedure, was more painful for the conventional ILA group versus the CCLADS group ($p < .001$). Table 4 shows that similar findings were obtained when the arches and teeth were analyzed separately.

Agewise and Sexwise Comparison

When agewise and sexwise comparisons were done within both groups, no difference in the heart rate values

Table 2. Archwise and Toothwise Analysis of Various Heart Rate Values Comparing Conventional ILA and CCLADS (Student's *t* Test)*

		Heart Rate Before Injection, beats/min		*Heart Rate During Injection, beats/min*		*Heart Rate During Extraction, beats/min*	
	No.	*Mean ± SD*	*p Value*	*Mean ± SD*	*p Value*	*Mean ± SD*	*p Value*
Maxillary arch							
Conventional ILA	24	99.7 ± 10.8	.25	110.1 ± 13.6	.03	115.5 ± 11.8	<.001
CCLADS	25	96.2 ± 10.4		102.3 ± 12.0		103.6 ± 14.2	
Mandibular arch							
Conventional ILA	27	93.9 ± 13.0	.66	101.8 ± 14.9	.56	103.8 ± 14.6	.37
CCLADS	26	95.3 ± 10.1		99.7 ± 12.1		100.5 ± 11.9	
Primary first molar							
Conventional ILA	33	95.5 ± 14.0	.97	103.2 ± 15.9	.31	107.1 ± 14.6	0.09
CCLADS	28	95.2 ± 11.5		99.3 ± 13.0		100.9 ± 13.6	
Primary second molar							
Conventional ILA	18	99.5 ± 7.6	.24	110.4 ± 11.5	.03	113.3 ± 13.7	.02
CCLADS	23	96.4 ± 8.5		102.9 ± 10.7		103.5 ± 12.5	

* ILA indicates intraligamentary anesthesia; CCLADS, computer-controlled local anesthetic delivery system.

and pain scores was found for either injection or extraction (Tables 5 and 6).

DISCUSSION

ILA is commonly considered in order to minimize the dose of anesthetic used, improve patient comfort, decrease residual soft tissue anesthesia, and provide successful dental anesthesia.[3,11] Because it does not numb the cheeks or lips, this lowers the risk of postoperative bite injuries.[5] Disadvantages with intraligamentary injections are difficulty in locating the precise site for needle placement, the pain of the injection, and leakage of bitter-tasting local anesthetic solution.[12] The intraligamentary injection can be performed using both conventional and specialized syringes.[3] Because specialized ILA syringes were not available in our department, we used a standard dental aspirating syringe for the conventional ILA injection.

Table 3. Median Values of FPS and SEM Scale During Injection and Extraction for Both Groups (Mann-Whitney Test)*

	Conventional ILA (n = 51)	*CCLADS (n = 51)*	*U Value*
FPS during injection	2.00	1.00	645.0 ($p < .001$)
FPS during extraction	3.00	1.00	729.0 ($p < .001$)
SEM scale during injection	4.00	3.00	562.0 ($p < .001$)
SEM scale during extraction	5.00	3.00	633.0 ($p < .001$)

* FPS indicates Faces Pain Scale–Revised; SEM, Sound, Eye, Motor.

In the present study, the conventional method and Wand-STA CCLADS of intraligamentary injection were compared for pain during needle insertion/injection and during primary molar extractions. Heart rate readings were recorded preprocedure, during injection, and during extraction. Heart rate can be increased because of anxiety or pain and therefore serves only as an indirect assessment of pain.[13] The pain scales used were the FPS and the SEM scale. The FPS was adapted from the Faces Pain Scale to make it possible to score the sensation of pain on the widely accepted 0–10 metric.[14,15] The SEM scale, introduced by Wright, is a more objective method and has been used in previous studies to measure comfort or pain in children.[6,10,16]

No significant difference in baseline heart rate values was seen between the groups. The difference in heart rate between groups when pooled during injection at all sites was found to be nonsignificant, pointing to a similar experience by patients during both injections. However, the heart rate during injection was found to be higher with the conventional ILA for the maxillary arch when both arches were analyzed separately. Higher heart rate values in the maxillary arch could be due to more injection sites (3, as compared to 2 in the mandibular arch). Additionally, the palatal injection may have been more painful than the buccal injections. Also, when the primary first and second molars were separately analyzed, it was found that heart rate values during injection were higher for the second molar during conventional ILA. This difference may be due to the difficult approach to the distal aspect of the second molar that can lead to incorrect positioning of the needle with conventional ILA, whereas correct position

Table 4. Archwise and Toothwise Analysis of Various Pain Scale Scores Comparing Conventional ILA and CCLADS (Median and Mean Rank Using Mann-Whitney Test)*

		FPS During Injection			*SEM During Injection*			*FPS During Extraction*			*SEM During Extraction*		
	No.	*Median*	*Mean Rank*	*U Value*	*Median*	*Mean Rank*	*U Value*	*Median*	*Mean Rank*	*U Value*	*Median*	*Mean Rank*	*U Value*
Maxillary arch													
Conventional ILA	24	2	30.62	165.0 (p = .005)	5	31.58	142.0 (p = .001)	2.5	29.92	182.0 (p = .015)	6	31.85	135.5 (p = .001)
CCLADS	25	1	19.60		3	18.68		2	20.28		3	18.42	
Mandibular arch													
Conventional ILA	27	2	34.13	158.5 (p < .001)	4	34.96	136.0 (p < .001)	3	33.31	180.5 (p = .002)	5	33.11	186.0 (p = .002)
CCLADS	26	1	19.6		3	18.73		1	20.4		4	20.65	
Primary first molar													
Conventional ILA	33	2	38.39	218.0 (p < .001)	4	37.7	241.0 (p = .001)	2	36.83	269.5 (p = .004)	5	37.2	257.5 (p = .002)
CCLADS	28	1	22.29		3	23.11		1	24.12		3	23.7	
Primary second molar													
Conventional ILA	18	2	26.64	105.0 (p = .006)	5	29.03	62.5 (p < .001)	3	26.33	111.0 (p = .009)	6.5	27.67	87.0 (p = .001)
CCLADS	23	1	16.59		3	14.72		1	16.83		4	15.78	

* ILA indicates conventional intraligamentary anesthesia; CCLADS, computer-controlled local anesthetic delivery system; FPS, Faces Pain Scale–Revised; SEM, Sound, Eye, Motor.

might be easier to achieve and maintain with the CCLADS as a result of the indicators. Heart rate values, though statistically significantly different at some time points, were still within physiological norms for these age groups, so they were not clinically significant.

Statistically significant higher SEM and FPS values were observed in the conventional ILA group compared to the CCLADS group, even when the values were further analyzed on the basis of maxillary and mandibular arch or type of molar, primary first or second. The uncontrolled pressure to forcibly move anesthetic solution with the conventional method could be the reason for more pain with this technique.[1,17] In the STA CCLADS, moderate pressure is applied, and the device can limit the maximum pressure applied.[17] During extraction, the values of SEM, FPS, and heart rate were significantly higher for conventional ILA as compared to CCLADS. This appears to indicate that CCLADS is more efficacious in delivering more profound dental anesthesia.

When assessing the cumulative pain scales and heart rate values, significantly less pain was recorded during injection with the CCLADS as compared to the conventional ILA injection. Similar results have been reported by Ran and Peretz,[7] who observed that children displayed better behavior using Wand intraligamentary injection, though they compared Wand PDL injection with conventional infiltration. Oztaş et al[8] also reported significantly lower pain scores during PDL injection with Wand, but they also compared Wand PDL with traditional inferior alveolar nerve block (IANB) injection in children.

ILA injection has been found to be suitable and effective for conducting permanent tooth extractions,[18,19] but studies reporting its effectiveness for primary molar extraction are limited. Tekin et al[9] compared ILA with IANB for first primary molar extractions and suggested the use of ILA as an alternate method for extraction of first primary molars. Their study compared ILA using the Citroject-CCLADS with traditional IANB, and the anesthetic agent was articaine.

Ran and Peretz[7] found the PDL injection with the Wand to be effective for various dental procedures, including extractions, but reported no significant difference between the efficacies of PDL injection and conventional infiltration. However, they compared Wand PDL with traditional infiltration, not traditional ILA.

Elbay et al[20] compared ILA and supraperiosteal injection using the Sleeper One CCLADS device and concluded that supraperiosteal injection was more effective than ILA for extractions. However, all injections were given by CCLADS (Sleeper One) device,

Table 5. Agewise Comparison of Variables in Both Groups*

	Conventional ILA			*CCLADS*		
	6–8 y (n = 20)	*9–13 y (n = 31)*	*p Value*	*6–8 y (n = 20)*	*9–13 y (n = 31)*	*p Value*
Heart rate before injection, mean ± SD, beats/min	96.8 ± 10.12	96.5 ± 13.68	.93†	94.4 ± 13.17	96.6 ± 7.85	.43†
Heart rate during injection, mean ± SD, beats/min	107.1 ± 15.24	104.9 ± 14.72	.61†	100.1 ± 15.99	101.5 ± 8.95	.69†
Heart rate during extraction, mean ± SD, beats/min	109.7 ± 15.86	109.0 ± 13.84	.87†	99.8 ± 16.08	103.5 ± 10.76	.31†
FPS during injection, median	2.0	2.0	1.0‡	1.0	0.0	.05‡
SEM during injection, median	4.5	4.0	.50‡	3.0	3.0	.20‡
FPS during extraction, median	3.5	2.0	.70‡	1.5	1.0	.25‡
SEM during extraction, median	5.5	5.0	.29‡	4.0	3.0	.58‡

* ILA indicates intraligamentary anesthesia; CCLADS, computer-controlled local anesthetic delivery system; FPS, Faces Pain Scale–Revised; SEM, Sound, Eye, Motor.
† Student's *t* test statistics.
‡ Mann-Whitney statistics.

and again, the comparison was between supraperiosteal injection and ILA.

Difficulty in positioning a conventional dental syringe needle during the ILA injection could be the reason for decreased efficacy of conventional ILA.[21] Further, it can be difficult to maintain correct needle placement throughout the injection.[22] There is no control over the amount of solution injected because both blockage and leakage during injection can occur.[17,23] In CCLADS, once the needle tip reaches the correct position, the system confirms it through an audible tone and visual display. Even during administration, displacement of the needle outside the target tissue is avoided through these continuous audio and visual signals. The CCLADS provides pressure-sensing feedback to indicate that there is no blockage or obstruction in the needle and no tissue clogging, and thus the correct amount of anesthetic agent is delivered.[17] Increased effectiveness of STA CCLADS could, therefore, be because the correct needle position is maintained throughout the injection and an adequate amount of anesthetic solution is delivered.

Many studies are available in the literature regarding various CCLADS devices, but there are only 3 available on the use of the Wand-STA for ILA. Kammerer et al[24] found higher injection pain and lesser anesthetic efficacy with STA CCLADS as compared to the Varioject system for restorative treatment in adults, though the difference was not statistically significant. In their study, dental students administered the injections, and they observed that STA CCLADS required appropriate training before use, especially for coordination between foot-pedal handling and syringe. These results cannot be compared with our results, as we used a conventional syringe and not the Varioject system.

Another study using STA was by Alamoudi et al,[25] who found ILA with STA CCLADS as effective as traditional IANB, but they used ILA for pulpotomy in primary molars, not for extraction as in our case. The

Table 6. Sexwise Comparison of Variables in Both Groups

	Conventional ILA			*CCLADS mean ± SD (median)*		
	Male (n = 35)	*Female (n = 16)*	*p* value	*Male (n = 34)*	*Female (n = 17)*	*p* value
Heart rate before injection, mean ± SD, beats/min	98.2 ± 11.67	93.2 ± 13.32	0.18†	96.0 ± 8.35	95.3 ± 13.46	0.84†
Heart rate during injection, mean ± SD, beats/min	107.7 ± 13.54	101.5 ± 16.97	0.16†	101.2 ± 10.36	101.5 ± 15.28	0.84†
Heart rate during extraction, mean ± SD, beats/min	111.3 ± 13.43	105.0 ± 16.23	0.14†	102.0 ± 10.45	102.1 ± 17.60	0.99†
FPS during injection, median	2.0	1.5	0.43‡	1.0	1.0	0.26‡
SEM during injection, median	4.0	4.0	0.14‡	3.0	3.0	0.85‡
FPS during extraction, median	3.0	2.0	0.41‡	1.5	1.0	0.61‡
SEM during extraction, median	6.0	5.0	0.50‡	3.0	4.0	0.89‡

* ILA indicates intraligamentary anesthesia; CCLADS, computer-controlled local anesthetic delivery system; FPS, Faces Pain Scale–Revised; SEM, Sound, Eye, Motor.
† Student's *t* test statistics.
‡ Mann-Whitney statistics.

third study was by Chenchugopal et al,[26] who used STA CCLADS with both articaine and lidocaine ILA injections for pulpectomies in primary molars.

There have been concerns that ILA, when used in primary teeth, may damage unerupted permanent teeth. This concern is primarily based on the study done by Brännström et al[27] in 1982, following which the pediatric dental community abandoned ILA. However, a recent study has shown no significant development of any disorder on the corresponding permanent molar buds following ILA delivered by the computerized method to primary molars.[28] Though the crestal bone and cementum can be damaged from needle trauma, such damage is generally minor and reversible.[29]

We observed no immediate adverse events in either of the groups. In many cases of conventional ILA, the patient complained of bitter-tasting solution in the mouth due to leakage of solution, which was not seen in any of the CCLADS cases.

ILA is contraindicated in patients with an increased risk of endocarditis.[30] A method of anesthesia should thus be decided by the patient's medical history, individual circumstances, and the planned procedure.[30] The minimal latency and short and controllable duration of ILA may be advantageous for shorter procedures in dentistry.[30] Time is an important factor in pediatric treatment. ILA technique provides reliable and rapid pain control with a very small quantity of anesthetic solution.[31]

The lack of availability of special syringe systems for conventional intraligamentary anesthesia was one of the limitations of our study. Further, we used single-tooth anesthesia only for extraction procedures. This area needs more research with respect to various operative/endodontic procedures and pain perception for its use in young children. Further, it is not clear if our heart rate differences were statistically valid, as our power analysis was based on pain scales and not on heart rate determination.

CONCLUSION

ILA can be an effective alternative means of local anesthesia for primary molar extractions. The Wand-STA system of computer-controlled local anesthetic delivery can make ILA more effective and less painful than ILA with a conventional dental syringe for extraction of primary molars.

REFERENCES

1. Eriksen HM, Aamdal H, Kerekes K. Periodontal ligament anesthesia. A clinical evaluation. *Endod Dent Traumatol*. 1986;2:267–269.

2. Malamed S. What's new in local anesthesia? *SAAD Dig*. 2009;25:4–14.

3. Meechan JG. Supplementary routes to local anesthesia. *Int Endod J*. 2002;35:885–896.

4. AAPD guidelines on use of local anesthesia for pediatric dental patients. *Clinical Guidelines. Pediatric Dentistry Reference Manual* 2015;37(6):199–205.

5. Endo T, Gabka J, Taubenheim L. Intraligamentary anesthesia: benefits and limitations. *Quintessence Int*. 2007; 37(8):e15–e25.

6. Amoudi NA, Feda M, Sharaf A, Hanno A, Farsi N. Assessment of the anesthetic effectiveness of anterior and middle superior alveolar injection using a computerized device versus traditional technique in children. *J Clin Pediatr Dent*. 2008;33(2):11–16.

7. Ran D, Peretz B. Assessing the pain reaction of children receiving periodontal ligament anesthesia using a computerized device (Wand). *J Clin Pediatr Dent*. 2003;27(3):247–250.

8. Oztaş N, Ulusu T, Bodur H, Doğan C. The Wand in pulp therapy: an alternative to inferior alveolar nerve block. *Quintessence Int*. 2005;36:559–564.

9. Tekin U, Ersin N, Oncag O, Bent B, Menderes M, Kocanali B. Comparison of inferior alveolar nerve block and intraligamentary anesthesia on the discomfort of children. *J Int Dent Med Res*. 2012;5(3):143–148.

10. Wright GZ, Weinberger SJ, Marti R, Plotzke O. The effectiveness of infiltration anesthesia in the mandibular primary molar region. *Pediatr Dent*.1991;13:278–283.

11. Biocanin V, Brkovic B, Milicic B, Stojic D. Efficacy and safety of intraseptal and periodontal ligament anesthesia achieved by computer-controlled articaine + epinephrine delivery: a dose-finding study. *Clin Oral Invest*. 2013;17:525–533.

12. White JJ, Reader A, Beck M, Meyers WJ. The periodontal ligament injection: a comparison of the efficacy in human maxillary and mandibular teeth. *J Endod*.1988;14: 508–514.

13. Allen KD, Kotil D, Larzelere RE, Hutfless S, Beiraghi S. Comparison of a computerized anesthesia device with a traditional syringe in preschool children. *Pediatr Dent*. 2002; 24:315–320.

14. Hicks CL, von Baeyer CL, Spafford P, van Korlaar I, Goodenough B. The Faces Pain Scale-Revised: toward a common metric in pediatric pain measurement. *Pain*. 2001;93: 173–183.

15. Bieri D, Reeve R, Champion GD, Addicoat L, Ziegler J. The Faces Pain Scale for the self-assessment of the severity of pain experienced by children: development, initial validation and preliminary investigation for ratio scale properties. *Pain*.1990;41:139–150.

16. Nakai Y, Milogram P, Mancl L, Coldwell S, Domoto PK, Ramsay DS. The effectiveness of local anesthesia in pediatric dental practice. *J Am Dent Assoc*. 2000;131(12):1699–1705.

17. Hochman MN. Single-tooth anesthesia: pressure sensing technology provides innovative advancement in the field of dental local anesthesia. *Compend Contin Educ Dent*. 2007;28: 186–193.

18. Edwards RW, Head TW. A clinical trial of intraligamentary anesthesia. *J Dent Res*. 1989;68(7):1210–1214.

19. Brkovik BMB, Savic M, Andric M, Jurisic M, Todorovic LJ. Intraseptal vs. periodontal ligament anesthesia for maxillary tooth extraction: quality of local anesthesia and hemodynamic response. *Clin Oral Invest*. 2010;14:675–681

20. Elbay US, Elbay M, Kaya E, Cilasun U. Intraligamentary and supraperiosteal anesthesia efficacy using a computer-controlled delivery system in mandibular molars. *J Clin Pediatr Dent*. 2016;40(3):193–199.

21. Meechan JG. Intraligamentary anesthesia. *J Dent*. 1992; 20:325–332.

22. Pashley EL, Nelson R, Pashley DH. Pressures created by dental injections. *J Dent Res*. 1981;60:1742–1748.

23. Dower JS Jr, Barniv ZM. Periodontal ligament injection: review and recommended technique. *Gen Dent*. 2004;52: 537–542.

24. Kammerer PW, Schiegnitz E, von Haussen T, et al. Clinical efficacy of a computerized device (STA) and a pressure syringe (INTRA VarioJect) for intraligamentary anesthesia. *Eur J Dent Educ*. 2015;19:16–22.

25. Alamoudi NM, Baghlaf KK, Elashiry EA, Farsi NM, El Derwi DA, Bayoumi AM. The effectiveness of computerized anesthesia in primary mandibular molar pulpotomy: a randomized controlled trial. *Quintessence Int*. 2016;47:217–224.

26. Chenchugopal M, Mungara J, Venumbaka NR, Elangovan A, Vijayakumar P, Rajendran S. In vivo evaluation of 4% articaine and 2% lignocaine intraligamentary injection administered with Single Tooth Anesthesia-Wand. *Contemp Clin Dent*. 2017;8:315–320.

27. Brännström M, Nordenvall KJ, Hedstrom KG. Periodontal tissue changes after intraligamentary anesthesia. *J Dent Child*. 1982;49:417–423.

28. Ashkenazi M, Blumer S, Eli I. Effectiveness of various modes of computerized delivery of local anesthesia in primary maxillary molars. *Pediatr Dent*. 2006;28:29–38.

29. Walton RE. Distribution of solutions with the periodontal ligament injection: clinical, anatomical, and histological evidence. *J Endod*. 1986;12(10):492–500.

30. Shabazfar N, Daublander M, Al-Nawas B, Kammerer PW. Periodontal ligament injection as alternative alveolar nerve block—meta-analysis of the literature from 1979 to 2012. *Clin Oral Invest*. 2014;18:351–358.

31. Haghgoo R, Taleghani F. Comparison of periodontal ligament injection and inferior alveolar nerve block in mandibular primary molars pulpotomy: a randomized control trial. *J Int Oral Health*. 2015;7(5):11–14.